Radiation Physics Note 40

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SUBJECT: Uranium Handling at the Hot Shop

The following is a summary of our experience during the prototype uranium calorimeter assembly at the Hot Shop.

Original Plan: The Hot Shop at IB #2 was selected as the site for assembly of a prototype of the DØ uranium calorimeter. The room was selected because there is good access control, a source of protective clothing, a hand and foot monitor, and a locker for street clothes in an adjacent change room. Arrangements were made with Technical Support (TS) to allow the Physics Section (PS) to hold the key to the shop for the duration of the assembly operation. Thus, TS personnel were prohibited from using the shop during this period.

All PS personnel involved in uranium handling were provided training by the Safety Section (SS) in the following areas, prior to entering the shop.

1. Physical, chemical and radioactive properties of uranium
2. External and internal radiation hazards
3. Physical security and accountability
4. Exposure control
5. Use of monitoring equipment
6. Emergency procedures

A set of control measures was developed and a list of guidelines for uranium handling was issued to all PS personnel involved. A copy of these guidelines is attached.

Account: The uranium was received and surveyed at Site 67 by SS personnel before delivery to the Hot Shop. Physics Section personnel began to log their entries into the shop on May 16. Inspection, selection and assembly of the plates was completed by June 13 without any unusual occurrences. Wet cleaning of the plates was considered, but not done, due to the complexity of the associated problems. Previously assembled units from Brookhaven were electronically tested in the shop during this time as well.

No incidents of personnel contamination were reported, and there were no problems with the new hand and foot monitor. The step off pads purchased for the entry door were quite useful, as they helped to keep the contamination from being tracked out onto the IB #2 main floor.

There were several problems of a minor nature which are noteworthy.

1. Although SS was notified when PS personnel were planning to enter the shop, this notification was usually too late to allow Rad Con to plan to cover the work. Backup was provided by the R. P. Staff group.

2. There was some confusion over the responsibility for procurement of protective clothing and pocket dosimeters.

3. The assemblies were transported in non-waterproof crates on a flatbed truck to Lab 3 and then to the Muon Lab. An unexpected thundershower caused a "near miss" contamination incident.

Monitoring Results: External whole body exposure was a very minor problem, as expected. No positive whole body film badge or pocket dosimeter results were recorded. A ring T.L.D. worn by an individual handling the plates detected an exposure of 40 millirem beta for the month of June. No other positive ring results were recorded.

The uranium present in the Hot Shop did not create a significant radiation field in the drafting offices above. Ambient levels in these offices remained below 0.25 mR/hr for the duration of the work.

Contamination of the floor and shop equipment became the major concern. Most of the wipes taken over the period May 16 to June 8 were reasonably low ($\sim$ 0.2 nCi/100 cm^2 β,γ). After the final assembly on June 14, there was considerably more contamination detected. One spot on the milling machine was 0.7 nCi/100 cm^2. After two attempts at decontamination, the mill was below 0.3 nCi/100 cm^2 and released to TS for normal hot shop use.

As mentioned, most of the wipes were not greater than 0.2 nCi/100 cm^2, or 2 x 10^{-12} Ci/cm^2, over a limited area of the floor or shop equipment. Since inhalation is the most serious route of exposure, lung exposure is the primary internal hazard. The atmospheric concentration (Ci/m^3) can be obtained from the measured surface contamination (Ci/m^2) using estimated values of the resuspension factor, which is defined as the ratio of these two numbers. Actually resuspension in an enclosed area is probably a function of the total amount of contaminant present rather than the concentration on any given limited area so that this result will be conservative.

Measured values of the resuspension factor vary between 10^{-4}-10^{-8} in units of m^{-1}, dependent upon details such as ventilation conditions, surface conditions, movement in the room, etc. Both Cember (Introduction to Health Physics, 2nd Edition, Pergamon Press, 1983) and Healy (Surface Contamination: Decision Levels, LA-4558-MS, Los Alamos Science Lab, 1971) suggest that a value of 10^{-6} m^{-1} is reasonable for the purpose of estimating the hazard. With this value, a measured surface contamination of 2 x 10^{-12} Ci/cm^2 gives an atmospheric concentration of 2 x 10^{-14} μCi/cm^3, which is only $\sim$ 3 x 10^{-4} of the maximum permissible concentration in air (MPC)a for natural uranium. The (MPC)a is based on the premise that an individual has sustained a continuous lung exposure of 300 mrem for a 40-hour week and has reached an equilibrium condition. Since a single individual could not have been exposed for more than 3/4 of a full 40-hour week, according to the PS log, the concentration of 3×10^{-4} of the (MPC)a might have resulted conservatively in a dose-equivalent of $3/4 \times 3 \times 10^{-4} \times 300 = .07$ mrem at most.

During the period that the Active Shop was utilized for uranium activity, the concentration of radon daughters in the air was continuously monitored by use of a Working Level Meter (WLM-300, EDA Instrument Co., Toronto, Canada). The Working Level (WL) is defined as any combination of the short-lived daughters of ^{222}Rn which in one liter of air result in the ultimate release of 1.3×10^5 MeV of alpha energy. Although it is derived from alpha energies released by the total decay of the daughters at radioactive equilibrium with 100 pCi of ^{222}Rn in one liter of air, the WL is independent of the state of daughter equilibrium. Roughly speaking, if the radon gas is in equilibrium with its daughters (which it seldom is except in closed spaces), a value of 0.3 WL corresponds to the (MPC)a for radon of 30 pCi/liter. However, the hazard of exposure to radon rests on the concentration of its daughters in the air. Generally corrective action is called for if atmospheric concentrations of radon daughters are more than 1 WL.

During the period 5/18-6/13 a maximum radon daughter concentration of $\sim$ 0.01 WL and a minimum of 0.0004 were observed, with average levels between 0.002 and 0.004 WL. There was, however, no apparent correlation between local maxima in the radon daughter concentrations and the hours during which the PS was actually working in the shop. The observed fluctuations are probably dependent on weather conditions rather than on any radon gas associated with the uranium activity. At present, although definite evidence is lacking, it appears that for the particular detector that was used "high" radon daughter levels are recorded during periods of high relative humidity, and low-levels with dry conditions.

Recommendations: Although the Hot Shop turned out to be a suitable location for work on this prototype, it is not recommended that this room be used for a uranium project of any larger scale. There is simply not enough floor space to accommodate larger plates, and larger assemblies. For future work, the assembly area chosen should have the following features:

1. Positive control over access to assure physical security and adequate contamination control.

2. A floor surface which is easily decontaminated. The sealed concrete floor in the Hot Shop was satisfactory.

3. A minimum of existing equipment in the area. Decontamination of the shop equipment proved difficult.

4. The room should be adequately ventilated. The value of the resuspension factor decreases as the total number of air changes per hour in the assembly area increases.

The following control measures imposed on uranium work should be modified based on our experience.

1. Pocket dosimeters do not appear to serve a useful purpose, and should no longer be required.

2. Dry vacuuming should be the method of choice for routine decontamination, as opposed to wet mopping.

3. Uranium to be transported on-site should be packaged such that it is protected from the elements.

4. Portable air-extraction devices (grab samplers) should not be used, since continuous sampling results indicate that grab sample lower limits of detection would be unacceptable.

5. Some continuous or passive integrating radon monitoring method needs to be employed during all uranium handling operations. The system of choice will depend on the scope of the future operation, and therefore cannot be recommended at this time.

6. A large scale calorimeter assembly will require that a radiation control technician be dedicated to this project.

<u>Guidelines for Handling of Uranium</u>

(1). All persons actively involved in the handling and assembly of the plates are required to wear film badges and ring badges. Visitors or observers are expected to wear film badges. Initially, assembly workers may be required to wear pocket dosimeters for periodic on-line dose measurements.

(2). Protective clothing - shoe covers, leather gloves, and coveralls - will be needed by all working personnel. Visitors could wear lab coats rather than coveralls.

(3). The Safety Section will set up and maintain radon detectors in the assembly and storage areas to monitor the possibly increased production of radon gas. Radon gas may also buildup within an enclosed space or container (e.g., the completed or partially completed calorimeter), and maybe released upon opening. Procedures that include monitoring of the air prior to opening will have to be established.

(4). Portable air-extraction equipment will be used to monitor for airborne radioactivity, particularly if it is obvious that oxide buildup is increasing.

(5). Routine contamination control procedures (wipes, etc.) will be performed daily by radiation control personnel. There will be one radiation control technician on hand at all times during assembly.

(6). There shall be no smoking, eating, drinking, or applying makeup in the storage, assembly, or change areas.

(7). All tools and other equipment used during assembly will be surveyed for contamination, and decontaminated if necessary by radiation safety personnel, before removal from the area.

(8). Upon leaving the assembly area, protective clothing will be removed in the change area and personnel must monitor themselves on the hand-and-foot monitors (or other instruments) provided. If contamination is found on skin or clothing, radiation safety personnel must be notified. Hands should be washed before leaving the change area.

(9). Clean up will be performed daily by use of wet mops (preferably) or a special vacuum cleaner. Provisions will have to be made for the disposal of contaminated water and/or dust if any.

(10). Persons taking part in the assembling and handling of the uranium plates will be trained as to these rules, the radiation and chemical hazards of uranium, and in the use of monitoring equipment.

(11). Machining, cutting, drilling, etc., of the uranium plates will <u>not</u> be allowed at Fermilab.

(12). Appropriate fire-extinguishing apparatus for both metal and other fires must be immediately available and easily assessible.